STORAGE AND HANDLING OF LUMBER

(At Wholesale and Retail Yards and Consumer Plants)

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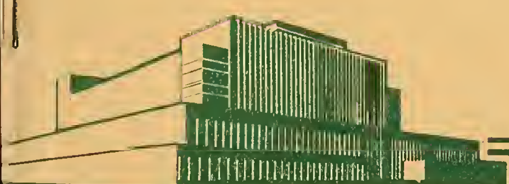

FOREST PRODUCTS LABORATORY
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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

STORAGE AND HANDLING OF LUMBER

(AT WHOLESALE AND RETAIL YARDS AND CONSUMER PLANTS)[1]

By

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Introduction

The development of machines, such as the fork-lift truck, that can be used to pile, unpile, and transport lumber has brought about revolutionary changes in storage and handling practices, the most notable being the handling of lumber in packages. Regardless of whether lumber is handled by mechanized equipment or by manual labor, however, the objectives of storage and handling are unchanged.

The objective of lumber storage is to maintain the lumber at, or bring it to, a moisture content suitable for its end use without depreciation. The objective of efficient lumber handling is to load, transport, unload, pile, and unpile lumber economically and without damaging it. Both of these objectives are easily attained if certain handling and storage practices are followed. Adequate protection of lumber in storage will help prevent damage by fungi or insects as well as changes in moisture content that make lumber unsuitable for its intended use. Mechanical equipment, if properly used, increases the ease and economy with which lumber is handled.

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[1] Although the information in this report is presented specifically for dealers and secondary processors, it also applies generally at sawmills.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

This report presents recommendations for the storage and handling of lumber that are based on experimental work and field experiences of the Forest Products Laboratory staff.[3]

Outdoor Storage

Lumber is often stored outdoors if shed or warehouse facilities are not available. Outdoor storage is satisfactory for some items, such as timbers and lumber for less exacting uses, provided certain precautions are taken. Kiln-dried lumber stored outdoors, however, may take on moisture from the air and no longer be suitable for its intended use. Outdoor storage may be utilized as an air-drying process if the lumber is in a green or nearly green condition.[4]

Some protection from the weather should be provided for lumber stored outdoors in order to help prevent wetting, warping, checking, and staining. Protection is more important for solid piles than for stickered piles, because rainwater can evaporate more readily from stickered than from solid piles. Rain that penetrates solid piles increases the moisture content of the lumber to a point where stain and decay can develop, although the moisture content may have been below 20 percent when the pile was erected. Some rain is likely to penetrate outdoor piles of lumber, despite protecting pile roofs, and consequently outdoor storage in solid piles is always hazardous. Exposure to dampness from ground water can be avoided if the lumber piles are kept clear of the ground, so that air can circulate between the lumber and the ground.

The Storage Yard

The storage yard is located preferably near the spot where the lumber is received, shipped, or used. The best location is on high ground that is level, well-drained, and remote from wind-obstructing objects, such as tall trees or buildings. A low site is likely to be sheltered from the full sweep of the winds and to be damp, conditions that may retard drying and promote stain and decay.

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[3] For additional information on storage and air drying, the reader is referred to publications listed at the back of this report.

[4] Since storage in stickered piles is equivalent to air drying, many of the illustrations used in this report are photographs taken in regular air-drying yards.

A good yard surface facilitates the transporting and handling of lumber and contributes to free air movement in the yard. The yard surface should be smooth and firm. It should be free from vegetation and debris, which interfere with air movement over the surface of the ground and may harbor stain and decay fungi. The best way to control vegetation is by using weed killers, many of which are on the market.

Materials such as cinders, gravel, shells, crushed stone, asphalt, or concrete may be used to surface or pave the alleys and other areas of the storage yard. Yards located on wet or swampy sites that will not hold surfacing or ordinary paving material may require paving with heavy planking. If the piles are built with a fork-lift truck, the alleys and additional areas beneath the piles where the vehicles travel should be surfaced or paved (fig. 1).

Rough surfaces cause wear and tear on transporting and piling machines. If lumber is handled in stickered packages, rough yard surfaces may also cause damage to the packages during handling and transporting, with subsequent difficulty in piling. Uneven yard surfaces are likely to impede accurate placing of the unit packages of lumber by fork-lift trucks.

A yard for storage or air drying of lumber is laid out in rows of piles forming blocks separated by alleys. A well-designed yard facilitates the flow of lumber in and out and helps in making and maintaining inventories. The actual yard layout is affected by the size and shape of the available area and by the machines and equipment used for transporting and piling. Alleys are generally narrower in yards where the piles are built by hand than they are in yards where the piles are built by machine. In hand-piled yards, the alleys are 16 to 20 feet wide, while in machine-piled yards they are 24 to 30 feet wide. The alleys not only provide routes for transporting lumber, but permit the movement of air through the yard and help block the spread of fire. Where lumber is hand stacked in rows parallel to the alleys, the boards in the piles are usually perpendicular to the alleys. Some hand-stacked piles are built with the boards parallel to the alleys, but this is uncommon. Where the piles are built by crane, the rows of piles and the boards within them may be either parallel or at right angles to the alleys. Where the piles are built by fork-lift truck, the rows are at right angles, and the boards in the piles are parallel to the alleys.

In a yard piled by hand or crane, the amount of lumber that can be placed between alleys is limited. With piling by fork-lift truck, there is no limit to the number of piles that can be placed between alleys because the fork-lift trucks can operate at any point between the alleys. Placing the piles in long rows between the alleys has one disadvantage -- some lumber may be buried and consequently held for a long time. Such lumber is likely to deteriorate. If long rows of piles are made, the

rows should be worked from both ends, so that, in general, lumber that is piled first is removed first. If lumber is piled by fork-lift trucks, in long rows accessible at one end only, the piles should be rearranged at intervals to release the inner piles. The consequent saving of lumber will probably pay the cost of the operation.

The direction of the main alleys, those from which the piles are built or taken down, is generally established by the nature of the available yard site. Insofar as ventilation and air movement through the yard are concerned, it probably makes no difference whether the main alleys run parallel or at right angles to the direction of the prevailing winds, because there are cross alleys that run at right angles to the main alleys. The important thing is to provide passages, alleys, and spaces between piles or rows of piles for the movement of air, irrespective of the wind direction. From the standpoint of drying after rainstorms or the melting of snow, it is advantageous to run the main alleys north and south. With main alleys running east and west, the snow or wet ground shaded by piles on the south side of the alleys will be slow to melt or dry, thus interfering with traffic.

Piling Methods

Whether lumber should be placed in solid piles for storing or in stickered piles for drying depends on its moisture content when it is received and on its intended use (figs. 2 and 3). The length of time the lumber is to be stored before use also has an influence on the type of pile.

Lumber at a moisture content of 20 percent or more that is to be held for any appreciable time, particularly in warm weather, should be piled with stickers. Such lumber is likely to deteriorate if held long in a solid pile, with mold and stain developing first. These impair the appearance of the lumber but may not prevent its use. Mold and stain, however, may be accompanied or followed by decay, which generally makes the lumber useless.

Even though the moisture content of the lumber is below 20 percent, it still may be desirable to lower its moisture content further because of end-use requirements. During the favorable drying season, in most parts of the United States, lumber piled outdoors with stickers can be reduced to a moisture content of 12 to 15 percent. Table 1 gives equilibrium moisture content values for wood exposed to the outdoor air at a city in each State and in several territories. The driest part of the country comprises the States of Wyoming, Colorado, Nevada, New Mexico, and Arizona. The dampest regions are the North Pacific and Gulf Coasts. According to

Weather Bureau records of mean monthly relative humidity, the lowest occurs at Tucson, Ariz., during the month of June, while the highest occurs at Seattle-Tacoma, Wash., in January. The corresponding wood equilibrium moisture content values are 4.6 and 21.0 percent. For the country as a whole, January and December are the dampest months, while June and October are the driest.

Thoroughly air-dried lumber will absorb moisture during cool and damp seasons if piled with stickers. In this case it is advantageous to solid pile, if the pile can be adequately protected from wetting.

Pile Foundations

Lumber in storage should not contact the ground; therefore, some type of pile foundation is required. The type needed will vary with different methods of piling. All foundations, however, should be strong and resistant to decay. They should be high enough off the ground to allow air that has circulated through stickered lumber piles to escape from below the pile, as well as to promote the general movement of air through the yard. The post- or pier-timber type of foundation is preferable to the solid built-up beam type, because it permits more air movement beneath the pile (fig. 4).

Foundation piers or posts can be made of concrete, masonry, preservative-treated blocks or pieces of any species, or untreated pieces of heartwood of decay-resistant species, such as baldcypress, redwood, or the cedars. If wood posts are used, they should be about 6 inches square of 6 to 8 inches in diameter. Posts or piers should be placed 4 to about 5 feet apart in the lengthwise direction and not over 6 feet apart in the lateral direction of the pile.

Posts or piers may be set in the ground and, if so, should extend below the frost line. They may also rest on the surface of the ground or on sleepers or mud sills laid on or slightly below the ground surface. Timbers in contact with the ground should be treated with a preservative, unless they consist of the heartwood of a decay-resistant species. The tops of the posts of a pile foundation should all be in a plane, either horizontal or sloped. If the foundation is sloped, the slope should be about 1 inch per foot of length from front to rear, with the rear posts of sufficient height to keep the underside of the boards in the first course 1 foot to 18 inches from the ground. If posts are not set in the ground, the foundation should be braced against lateral tipping (fig. 4).

The posts support stringers that run lengthwise of the pile. These may be steel I-beams, railroad rails, or timbers. Timber stringers should

be about 6 by 8 inches, set on edge, and treated with a preservative. The stringers carry the cross beams, which should be spaced so as to fall directly beneath tiers of stickers. If stringers are not used, the cross beams rest on top of the posts. The cross beams may be long enough for one or a number of piles. With stickered piles of lumber, stringers are an advantage because the position of the cross beams can be changed to accommodate any sticker spacing.

Foundations for hand-stacked piles are generally perpendicular to the alleys and slope from front to rear.

Foundations for packaged lumber are usually horizontal rather than sloped. For piles built with cranes, the foundations may be similar to those for piles built by hand, but the boards in the packages are frequently parallel to the alleys. In piles built with fork-lift trucks, the boards in the packages are always parallel to the alleys. In addition, the pile foundations vary considerably from those used with hand-stacked or crane-built piles. If the foundations are fixed and much over 6 inches in height and if the rows are more than two piles long (fig. 5), a passageway must be provided between the foundation timbers for the fork-lift truck.

The space needed for this passageway, which is from 7-1/2 to 9 feet wide, affects not only the design of the pile foundation but the design of the whole pile. This applies particularly to storage piles made of stickered packages, because, in these piles, all supporting elements should be properly spaced and in good alinement to prevent sagging, which may result in warped boards.

When piling is done with cranes or fork-lift trucks, regular pile foundations are often dispensed with, and the piles are placed on timbers resting on the ground. When a fork-lift truck is used, the cross beams are commonly the bolsters, or separators, used in handling and piling. The bolsters are usually about 4 by 4 inches in cross section. They can be placed in position just before the pile is built or left on the ground, because the fork-lift truck has sufficient clearance to pass over them. If the storage-yard surface is well graded and surfaced, bolsters provide good mechanical support for the piles of lumber. From the standpoint of good drying and satisfactory control of moisture content, however, the resulting low pile foundations are a disadvantage.

Type of Piles

Solid piles.--The foundations for a hand-stacked or crane-built solid pile may consist of two or three cross beams laid on the ground or

carried on piers or stringers (fig. 2). The foundation should provide a clearance of 12 to 18 inches between the bottom of the first course of lumber and the ground. If two cross beams are used, they should be placed roughly at the first- and third-quarter points in the length of the lumber. If they are placed farther apart, the pile is likely to sag in the middle. With three cross beams, one should be in the center and the others at or near each end. In piling with fork-lift trucks, fixed center cross beams thicker than about 6 inches cannot be used, because the truck cannot straddle them. In this case, the pile may be supported by two cross beams or long timbers, or by two cross beams or timbers plus a center support that is put in place just before the pile is erected.

Tie pieces are put into a solid hand-stacked pile to keep the outer parts from falling over. They also are often used to separate certain quantities of lumber in the piles. Although two supports are generally sufficient for a solid pile of lumber, the tie pieces should be vertically alined with the corresponding cross beams of the pile foundation. If the tie pieces are not so alined, the lumber may sag. The number of tie pieces need not be limited, however, to the number of cross beams.

If cranes or fork-lift trucks are used, bolsters at least 3 inches thick are placed between the packages (fig. 2), in order that the forks or slings of the machines may be inserted under each package. The bolsters should be alined with the cross beams or timbers of the pile foundation.

The width and height of solid storage piles are determined by the method of piling, the amount of lumber to be stored in a given yard area, and whether roofing is to be provided. A wide, low pile takes up more room than a narrow, tall pile and requires more roofing material for a given amount of lumber. The width of a hand-stacked pile is unlimited, but its height is generally limited to about 15 feet, unless lumber-elevating devices are used. The width of piles built with cranes or fork-lift trucks is established by the width of the packages placed in the piles. These generally are 3 to 6 feet wide, with 3-1/2 to 4 feet the commonest widths. The height limit in machine piling is about 30 feet. Piles that are much higher may tip over, or their tremendous weight may crush tie pieces or boards in the lower parts.

Stickered piles.--The construction of a stickered storage pile is considerably more complex than that of a solid one. Stickered storage piles must be provided with good foundation support, which is somewhat more difficult than with solid piles, because stickered packages are not so stiff as solid packages. In addition, air should circulate around and within the pile, coming in contact with the faces of each piece.

To permit air to circulate thus, stickers or crossers are placed between consecutive layers, or courses, of lumber. Basically, the function of the stickers is to provide columns for the support of the pile, to separate the courses of lumber, and to restrain warping by holding the boards in a flat position. Stickers are of two classes, special stickers and stock stickers (figs. 5 and 6). Stock stickers are boards of the same kind of lumber that makes up the pile. When stock stickers are used, the lumber is said to be self-stickered. Special stickers may be made from any species, but sapwood is undesirable because it may harbor stain organisms. Special stickers for softwoods are often nominal 1 inch thick by 4 inches wide, and for hardwoods nominal 1 inch thick by 1-1/4 to 2 inches wide. Stickers of either type should be of uniform thickness. If stock stickers are used, the length of the boards used for stickers determines the width of the pile.

When the prevention of staining and checking is important, special stickers that are thoroughly air dried should be used. In hand-stacked piles of low-grade lumber destined for rough end use, the use of stock stickers permits more lumber to be piled in a given space and in less time than when special stickers are used. The use of stock stickers makes unnecessary the investment in special stickers and the cost of replacement, as well as the cost of handling and storing them, because the stickers are sold or used with the rest of the lumber when the pile is taken down.

The number and position of the stickers may have an important bearing on the development of drying defects. The number of stickers needed varies with the species, thickness, type, and grade of lumber piled. Lumber cut from a species that is prone to warp needs more stickers than lumber cut from other species. Thin lumber needs more stickers than thick lumber to reduce warping. Lumber that is susceptible to staining should be piled with a minimum number of stickers. High-grade lumber should be piled with more stickers than low-grade lumber of the same species. To support the pile properly, the stickers should be alined vertically with the cross beams of the pile foundation (fig. 5).

With softwoods, which generally warp less than hardwoods, fewer stickers are needed to prevent sagging and warping. They should, however, be wider than those used for hardwoods to provide bearing surfaces sufficient to avoid crushing. In hand-stacked piles, from 2 to 9 stickers are used with 16-foot softwoods. If 2 are used, they are spaced 8 to 9 feet apart, and the board ends are allowed to overhang at both ends of the pile. Commonly 3 or 5 tiers of stickers are used for 16-foot lumber. The limits for 16-foot hardwood lumber in hand-stacked piles are 5 to 17 tiers of stickers. The stickers for hardwood lumber are often spaced 16 inches to 2 feet apart.

The stickers in each tier should be in vertical alinement or should follow the pitch of the pile in pitched hand-stacked piles. If the stickers are not alined, the weight of the pile above will bear on some boards between stickers, thereby causing sagging (figs. 7 and 8) and warping. Since sticker guides are used only infrequently in hand stacking, the alinement of the stickers generally depends on the care and skill of the workmen.

Stickers used in packages are almost exclusively of the special type. In general, the narrowness of the package prohibits the use of stock stickers. Special stickers for packages are often made from dressed nominal 1-inch stock, and 1-1/2 to 2 inches wide. The number and spacing of the stickers in packages are about the same as for hand-stacked piles. Packages of lumber should be built in stacking racks or jigs equipped with sticker guides (fig. 9). The sticker guides are generally on 1 side only. The use of sticker guides is essential in the building of packages to assure good sticker alinement and uniform sticker spacing. Unless these requirements are met, properly supported storage piles consisting of several packages cannot be made.

A stickered storage pile may be piled horizontally or with a slope. It is customary to slope hand-stacked piles from front to rear. The construction of the pile foundations assures a slope of about 1 inch per foot of pile length. In order to utilize the possible advantage of the slope, the pile should also be pitched so that the top overhangs at the front end (fig. 3). The pitch is usually equal to the slope, or 1 inch per foot of height. The pitch, in combination with a projecting pile roof, helps to prevent rain from entering the front of the pile. The slope tends to cause water that may have entered the pile to work toward the rear and eventually to drip from the rear ends of the boards. The slope and pitch are advantageous if the pile has protruding or overhanging ends of long boards at the rear. Rain falling on these board ends will run to the rear end and drip off rather than running into the pile. Solid storage piles in which the board ends are flush with one end of the pile but protrude at the other, may also benefit from sloping and pitching. The slope and pitch of a pile may compensate to some degree for a faulty pile roof.

Machine-built piles are usually horizontal. Building sloped and pitched piles by fork-lift trucks requires that the machines be equipped with laterally tilting forks or that the yard surface be specially graded (fig. 1). It also requires that a pitch be built into the packages.

While it is preferable to have the long boards in the lower and outer parts of solid piles, it is highly important that they be placed there in stickered piles. The manner of placing the boards affects the mechanical support and stability of the pile and the movement of air within it.

The rate and uniformity of drying are connected directly with the circulation of air within the pile. If the boards of a stickered storage pile are all of one length, it is easy to build a stable pile. With boards of two or more lengths, however, care is required in placing them.

Lumber of more than one length should be box piled. A box pile appears square at both ends and is made by placing the longest boards in the outer vertical tiers of lumber, with other tiers of long boards, if there are enough of them, distributed uniformly across the width of the pile (fig. 10). Tiers of short boards are placed between the tiers of long boards, and, if possible, all the boards of a tier should be of the same length. The ends of the short boards may all be placed flush with the front of the pile, or preferably, they are alternately placed flush with the front and rear in adjacent tiers. The pieces within a tier of short boards may be placed alternately flush with either end of the pile. A box pile has no projecting or unsupported board ends and no unsupported sticker ends. Box piling for stability is important in both hand-stacked and machine-built piles, but it is more critical in the construction of stickered packages for storage piles, where the ratio of pile height to width is generally much greater than for hand-stacked piles.

Within the pile, air moves horizontally through the spaces formed by the stickers. In hand-stacked piles, spaces can be left between the board edges to form vertical passages for air. These passages, or flues, are 1 to 6 inches in width (fig. 6). The sum of the widths of the flues should equal about 20 percent of the width of the pile. Flues are somewhat more difficult to build into packages. If the packages are not over 4 feet wide, flues are probably not needed. If 3- to 4-foot spaces are provided between the sides and ends of adjacent storage piles, the movement of air through these spaces will induce horizontal movement through the packages, thus accomplishing drying.

Pile Roofs

A good pile roof will shield the boards in the uppermost courses from direct sunshine and will also shade the sides and ends of the upper part of the pile to some extent. The lower parts of the piles are shaded by nearby piles. A watertight, properly pitched pile roof will also protect the pile from rain and snow. The drip from the lower end should fall clear of the pile.

Roofs can reduce or eliminate depreciation losses caused by exposure to the weather. The likelihood that boards will check, split, or warp because of alternate wetting by rain or snow and rapid drying in direct sunshine is considerably decreased. In unroofed storage piles the

checks and splits increase in size with continued exposure of the lumber. Roofs also hinder water from seeping into the piles to retard drying and promote stain, mold, and decay. Any water that does seep in will evaporate readily in stickered piles, but will remain in solid piles.

A pile roof is more effective if it projects at the front, rear, and sides of the pile (fig. 3). For a pitched and sloped hand-stacked pile, the roof should project about 1 foot at the front, 2-1/2 feet at the rear, and 6 inches at the sides. For a level or horizontal pile, the projection should be about 2 feet at both ends and about 6 inches at the sides. If unit packages are piled by fork-lift truck and the roof is placed on the upper unit package before it is placed on the pile, it is impractical to have the roof project on the side toward the machine. For sloped hand-stacked piles, the pitch of the roof generally equals the slope of the pile, about 1 inch per foot of length. For horizontal piles, one end or the center of the roof must be elevated if a pitch is to be obtained. In all cases, the roof should be raised several inches above the top course of lumber to permit movement of air between the roof and the top of the pile.

Various methods are used to construct pile roofs. Roofs are commonly made from low-grade boards laid in single layer, single length; single layer, double length; double layer, single length; or double layer, double length.

To lay a double-layer, double-length roof, two crosspieces, about 1 foot longer than the width of the pile, are placed on the top course of lumber at the center and rear end of a solid pile, or directly over the center and rear tiers of stickers if the pile is stickered, in order to raise the roof 4 to 6 inches above the lumber. For a 16-foot-long pile, a layer of boards at least 11 feet long is laid on the crosspieces, with narrow spaces between the board edges. The ends of these boards should project about 2-1/2 feet beyond the rear crosspiece and about 6 inches beyond the center crosspiece. A second layer of similar boards is laid to cover the spaces in the first layer. The front portion of the roof is made from boards at least 9-1/2 feet long, laid in like manner. At the center of the pile, ends of the boards of the front part of the roof rest upon the front ends of the boards of the rear portion, and overlap them by about 1 foot. If the front portion of the roof is composed of boards longer than 9-1/2 feet, the projection at the front of the pile, usually about 1 foot, or the amount of overlap at the center may be increased. In order to obtain the proper roof pitch, the crosspiece at the front of the pile or above the first tier of stickers should raise the roof about 8 inches above the top course of lumber. To prevent the roof from being blown off by wind, tie pieces of 2 by 4 or 4 by 4 inches may be laid crosswise at the front, middle, and rear of the pile and fastened by wires or springs to the pile about 10 courses below the top.

Piles of packages, either solid or stickered, may also be roofed with double layers of boards. Since package piles are often horizontal, provision for sufficient pitch to the roof is more difficult than with sloped hand-stacked piles. To obtain a roof pitch of 1 to 12 in a 16-foot pile, a roof of a double layer of boards would have to be elevated 18 inches at one end for a single-section roof and 20 inches for a double-section roof if the other end were elevated 2 inches. To raise one end of the roof to these heights above the pile is not practical.

Board roofs on horizontal piles can be elevated in the middle and made to pitch toward each end. This would require a two-section roof with an elevation of 10 inches at the middle, if each end were supported 2 inches above the pile, to secure a roof pitch of 1 in 12. Elevating the roof at the middle seems more practical than elevating at one end for roofing horizontal piles with loose boards.

Pile roofs may be made from panels consisting of boards nailed to crosspieces or a light timber framework. Panel roofs may be designed to pitch from end to end or from the middle toward both ends. The boards in the panels are often placed edge to edge, with narrow boards or battens nailed over the joints. Panels of this sort are more commonly used on piles containing narrow or stickered packages. A single-length panel or two overlapping panels may be used to cover the pile. Panel roofs may be handled manually or with a crane or fork-lift truck and are placed on the top solid or unit package before it is placed on the pile.

Building paper or roll roofing may be combined with loose boards to form a pile roof. The boards in this type of roof should be laid in a single layer, edge to edge. If two lengths of boards are needed, their ends may be butted together over a central crosspiece. Since this type of roof is watertight, the pitch can be less than in a type composed of loosely laid boards. The building paper or roll roofing can be lapped like shingles or run lengthwise of the pile. Pieces of wood should be placed on the roofing lengthwise of the pile to keep it in place. If building paper of relatively short life is used, it should probably be discarded when the pile is taken down. Longer-lived roll roofing can be saved and reused. Boards and roll roofing can be combined in a panel type of roof. When used in this fashion, the roll roofing should last for a number of years.

Corrugated metal sheets of aluminum or galvanized steel may be fastened to a wooden framework to form roof panels. The panels may be handled by machine or by hand.

A solid pile of lumber is often covered with a tarpaulin or a canvas, rather than with a roof.

Indoor Storage

Open Sheds

An open shed may be likened to a storage yard with a roof. All lumber except kiln-dried lumber or such products as plywood can be advantageously stored in open sheds. Lumber that is received in the green or inadequately dried state can be stored in an open shed. The atmospheric conditions within an open shed are similar to those found outdoors, and, if the outdoor air can circulate within the piles, the lumber will dry much as it does in an outdoor pile. Most of the discussion pertaining to piles in the storage yard applies to piles within an open shed. Of course, since the shed roof will protect the piles from rain and snow, there is no object in sloping the pile foundations or in sloping or pitching the piles.

An open shed may consist of a roof with no side or end walls, or may be open on 1 side only. The lumber is piled and unpiled from the open sides, making the areas adjacent to the shed resemble the alleys of the storage yard (fig. 11). Where hand-stacked piles are in wide sheds, it is necessary to have an additional aisle or aisles running through the shed. If the piles are built with fork-lift truck, the rows of piles may run from one side of the shed to the other, in bays between the roof supports. Cranes operating within open storage sheds are generally of the monorail or bridge type. Piles made with cranes can be arranged in any desired fashion.

Closed Sheds

Closed sheds are used primarily for the storage of well-seasoned lumber, plywood, and other stock destined for high-grade uses. The object during storage is to prevent regain of moisture by the dry stock. As a consequence, lumber and other items should be piled solid, with only sufficient strips or separators to make stable piles or to designate quantities, grades, or items.

Kiln-dried lumber stored in an unheated closed shed will ordinarily adsorb some moisture. Moisture is adsorbed because the mean moisture content of the wood is usually lower than the equilibrium moisture content corresponding to the atmosphere within the shed. Figure 12 shows the moisture adsorption of solid piles of kiln-dried southern yellow pine flooring. The lumber stored outdoors increased in moisture content from about 8 to 13 percent during 18 months. The average moisture content of the lumber in similar piles stored in different sheds,

changed from about 7.5 to 10.5 percent during the same period. The exposed ends, edges, and faces, quickly attain a moisture content in balance with the temperature and relative humidity of the atmosphere within the shed. Following this the moisture diffuses inward. The diffusion is most rapid along the grain inwards from the ends. This whole process is slow, and it would take several years for the adsorbed moisture to penetrate the entire solid pile. If there are spaces within the pile such as would occur with lumber milled to a pattern, the moisture pick up will proceed more rapidly in the interior of the pile.

The adsorption of moisture in the ends of boards or stock run to pattern, strip flooring for example, may prove detrimental to efficient use. The ends swell with the adsorption of moisture and the pieces are wider at the ends than they are over the rest of the length. When the pieces are laid the ends make contact, leaving an open crack over the remainder of the length. To close the crack, it is necessary to drive the pieces together with a force sufficient to crush the edges at the ends. Subsequently openings will appear at and near the ends. If kiln-dried lumber for flooring or any other pattern is stored under like circumstances, and then run to pattern, the ends will be narrower than the gage when the material reaches a low and uniform moisture content.

Although the average moisture content of kiln-dried lumber may increase during storage in an unheated shed, the moisture content condition of the pile of lumber may be improved. This takes place when the batch of lumber consists of numerous boards both above and below the average moisture content. In the interior of the solid pile or package, the moisture from the wetter boards is transferred to the drier boards, thus bringing about a more uniform distribution of moisture. This is advantageous, for it is generally the wettest boards that cause most trouble when the lumber is put in service. Table 2 gives the changes in average moisture content and maximum moisture content of the wettest board, in lots of longleaf and shortleaf pine, rough and dressed, solid piled and stored in closed, unheated sheds for 90 days following kiln drying.[2] The average increases in the mean moisture content values were 1.6 percent for the longleaf, and 3.7 percent for the shortleaf. The average decrease in the moisture content of the wettest board was 2.8 percent for the longleaf and 3.6 percent for the shortleaf. Decreasing the moisture content of the wettest board makes the moisture content of the batch more uniform.

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[2] Portion of table 11 from "Standard Commercial Moisture Specifications for Southern Yellow Pine Lumber, Effect of Present Seasoning and Storing Practices on the Moisture Content of Southern Yellow Pine at Time of Shipment," by W. Karl Loughborough and O. W. Torgeson, Sept. 14, 1929.

Closed sheds should be floored, preferably with concrete, asphalt, wood block, or planking. Loose surfacing is less satisfactory. An earthen floor, particularly if the shed stands on a low, damp site, can cause damp conditions within a closed shed. For this reason, closed sheds should be located on dry, well-drained sites. A paved surface with good drainage away from the shed will help secure a dry floor. Ventilation of the shed should be provided by adjustable openings in the roof and walls.

The piles are laid out in rows, with aisles between. Fork-lift trucks require aisles at least 24 feet wide for turning with a 16-foot load. When the material is piled by hand, the aisles may be narrower. If the shed is equipped with an overhead bridge crane, the piles may be arranged in any way, provided the piles are accessible and provision is made for air circulation to keep temperatures uniform. Since air circulation is not needed to accomplish drying, adequate spacing is 1 to 2 feet between hand-stacked piles and 2 feet between rows and 1 foot between piles for machine-stacked package piles.

Pile foundations in a closed shed should be high enough to permit air to circulate beneath the piles. Stagnant air underneath the piles is likely to be cooler and damper than the air in the rest of the shed, hence may increase the moisture content of the wood in the lower parts of the pile. If the floor is earth or is surfaced with some loose material, the foundations should elevate the pile about 1 foot; if the floor is paved, a clearance of about 6 inches is sufficient.

Storage piles of seasoned lumber or other items in a closed shed may be placed on two to three timbers, spaced so as to provide good support to the piles. If fork-lift trucks are used, timber foundations more than 6 inches high must be arranged to provide an operating space. A removable center timber can be used within this space, as with outdoor piles (fig. 5).

Lumber is sometimes stacked by hand in racks or bins consisting of uprights and cross beams that support batches of lumber one above the other. Each bin can be loaded or unloaded independently.

Closed sheds as well as open sheds may be used to store lumber waiting to be kiln dried. The lumber is piled with stickers on kiln trucks or in packages. The shed roofs protect the lumber from sunshine and wetting and the lumber can dry (fig. 13).

Unheated sheds.--If a closed shed is unheated, the temperature inside will be somewhat higher than that outdoors because of heat from the sun. With proper ventilation, the mean relative humidity within the shed will be somewhat lower than that of the outdoor air. Therefore, wood can be held at a lower moisture content when stored inside an unheated closed shed than when it is stored outdoors. The amount of ventilation in an unheated shed should be increased in dry weather and decreased in damp weather.

From a theoretical standpoint an unheated closed shed full of thoroughly kiln-dried lumber should not be ventilated if there is no source of moisture within the shed except that contained within the lumber. In this case, the moisture content of the lumber will be below the equilibrium moisture content consistent with the outdoor air, even during hot, dry weather. Ventilation is therefore a safety measure designed to eliminate moisture introduced through the shed floor.

Heated sheds.--The efficiency of a closed shed in maintaining a low moisture content in lumber and other items for high-grade end uses is enhanced if it is heated as weather conditions require. Heat is most useful when the outdoor air is cool and damp. In an unheated closed shed, the only possible procedure during cool, damp weather is to close the ventilators and hope that the unfavorable weather will not be prolonged. When a source of heat is available, a low relative humidity within the shed, and consequently a low equilibrium moisture content for the wood, can be maintained by increasing the shed temperature by the required amount.

The most practical way to supply heat to a closed storage shed is by means of steam coils, radiators, or unit heaters. The heating system need not have a large capacity, since only enough heat usually is required to raise the shed temperature 10° to 20° F. above the outdoor temperature, with a minimum of 32° F. to prevent freezing of water in the return lines and traps of the heating system. The heating system should be arranged so that the temperature throughout the shed is uniform. Fans placed at strategic points help to maintain uniform conditions throughout the shed.

The heat supply may be controlled manually or automatically. A handy device for measuring conditions within a storage shed with heat supply manually controlled consists of a piece of wood whose weight is adjusted so that it indicates the equilibrium moisture content corresponding to the atmosphere. For example, if the weight has been adjusted so that the ovendry weight of the piece is 100 grams, then a weight of 108 grams indicates 8 percent moisture content (fig. 14). When the indicated moisture content inside the shed is higher than desired, the heat should be turned on.

A hygrostat can be adapted to maintain conditions of temperature and relative humidity corresponding to a given equilibrium moisture content for the wood. As the temperature within the shed drops, the relative humidity increases, causing the hygroscopic element, which in this case is wood, to adsorb moisture and swell. The swelling of the element activates a mechanism that turns on the heat. When the temperature is increased and the relative humidity decreases, the process is reversed. With manual control, a simple general rule is to maintain the shed temperature 10° F. above the outdoor temperature to maintain wood at 10 percent moisture content, and 20° F. above the outdoor temperature to maintain a 7 percent moisture content. This rule applies roughly to winter conditions in the northern part of the United States.

Figure 15 shows how heating or cooling the air affects the relative humidity of the air and the equilibrium moisture content of wood. For example, assume that the air outdoors or within a shed has a temperature of 30° F. and a relative humidity of 75 percent. According to figure 12, the corresponding equilibrium moisture content of the wood is 15 percent. If this air is heated to a temperature of 45° F. and no moisture is added from sources within the shed, the relative humidity is reduced to about 41 percent and the equilibrium moisture content of the wood to 8 percent (see dotted lines in figure 15). Heating sheds according to this system eliminates the need for steam sprays, water sprays, desiccants, or refrigeration to control the moisture content of lumber.

Handling Operations

Handling operations include all unloading, loading, stacking, and transportation of material. Even if machines are employed to the fullest extent, there still may remain considerable manual handling of individual boards. Individual boards, however, can be moved for relatively short distances by several types of conveyors. The shape of lumber lends itself to packaging for machine handling. Although the packages themselves are usually made up by hand, once the package is built, the handling of individual boards is eliminated until the package is broken down.

Handling of Individual Boards or Loads

Equipment to handle single boards is limited. Dead rolls and bars are used to unload boards from a railroad box car. The roll or bar supports the piece while it is shoved or pulled laterally and holds it at a certain elevation, so that it may be grasped and lowered onto a pile or

placed in some conveyance. Inclines equipped with dead rolls are also used to unload lumber piece by piece. Conveyor belts (fig. 16) and chains are other devices used to move boards, dimension, and timbers in unloading and other plant operations.

Loads of boards are transported by motor trucks and by trailers, dollies, railroad flat cars, narrow-gage track cars, or wagons hauled by tractors or motor trucks. Some loads of lumber on narrow-gage track cars are moved by hand, on slightly inclined tracks. Draft animals are still used to a slight extent to haul loaded dollies or wagons. The beds, platforms, or bunks of conveyances are often fitted with rollers to facilitate loading. Trailers, dollies, and wagons hauled by other vehicles can be loaded piece by piece without much loss of efficiency. When motor trucks are used, however, building up an entire load as a unit avoids tying up the truck during loading. The load may be made up on rollers and hauled by cable and winch over the rollers onto the bed of the truck, or it may be built on temporary supports that are knocked down when the vehicle backs against them.

Loads of loose lumber carried on trailers, dollies, or wagons are generally unloaded by hand. Dump trucks are sometimes used, and the loads are dumped on the ground. Loads resting on rollers may be dumped by suddenly starting the vehicle and literally running it out from beneath the load. Loads of lumber that are dumped should be strapped or chained to keep the loads intact. Dumping of whole loads, however, is likely to result in breakage and other damage, such as driving of grit into boards.

Handling of Lumber in Packages

Lumber is often received in solid, strapped packages. Strapped packages are preferred for shipment because strapping prevents movement of boards. Sometimes unstrapped packages shift so much in transit that they cannot be unloaded by machine (fig. 17). Even well-strapped packages sometimes shift and are damaged during shipment.

Lumber packages are shipped on railroad flat cars or gondolas or on trucks. Railroad cars commonly carry 18 packages, while trucks carry 2 to 4 packages. The packages are generally about 4 feet wide, so that two of them equal a width suitable for a railroad car or truck. Each package contains lumber of one grade and usually of one width. Boards of different lengths are generally included within a package. Packages are sometimes made up to contain a certain quantity of lumber. A 4- by 4- by 16-foot solid package contains approximately 3,000 board feet, a 3-1/2- by 3-1/2- by 16-foot package somewhat over 2,000 board feet, and

a 3-1/2- by 2- by 16-foot package about 1,250 board feet. Some organizations specify the number of pieces of certain dimensions to be put in the packages.

A railroad car or truck carrying packages of lumber should be loaded so that the shipment can be unloaded by some type of crane (fig. 18) or by fork-lift truck. The tiers of packages should be separated with dunnage lumber at least 3 inches thick for machine handling. Unstrapped packages, which are often used in short hauls by truck, should have pieces of wood placed between their vertical faces.

Seasoned lumber that is shipped in solid-package form in open railroad cars should be protected from rain and snow. A sheet of asphalted building paper placed just beneath the top course of lumber will help keep water from soaking into the pile. The top course of boards, together with the straps around the packages, keeps the paper in place. If one-width lumber is contained in the package, a method of preventing water entry is to place one less board in the top course and to lay each board of the top course over the joints of the rest of the package. Spraying the surfaces of the package with a liquid that turns into a plastic coating is another method of protecting the lumber from wetting. Green lumber should not be shipped in solid packages during warm weather unless it has been dipped in an antistain solution.

Strapped, solid packages of thoroughly seasoned lumber can be left intact throughout handling, transporting, and storing operations until they reach the shop. Strapped, solid packages or green or inadequately seasoned lumber should be opened and the lumber piled with stickers between course for air drying in a storage yard or open shed.

For some years, cranes have been used to unload, pile, and unpile and straddle trucks or carriers to transport solid or stickered packages of lumber. Recently, fork-lift trucks -- motor trucks equipped with elevating forks -- have largely replaced cranes for unloading, piling, and unpiling (fig. 1). Fork-lift trucks can also be used for transporting, although they are not so efficient for this purpose as straddle trucks (fig. 19). The versatility of fork-lift trucks, however, often justifies their exclusive use, particularly at small storage yards. If a large volume of lumber is used, a combination of fork-lift trucks and straddle trucks is efficient -- the fork-lift trucks for unloading, piling, and unpiling and the straddle trucks for transporting.

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Table 1.-- Equilibrium Moisture Content of Wood, Exposed to Outdoor Atmosphere, in the United States and Territories

Location	Equilibrium moisture content[1]											
	January	February	March	April	May	June	July	August	September	October	November	December
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Portland, Maine	16.9	15.5	15.8	14.8	15.0	13.4	13.9	15.5	17.2	15.4	16.3	14.9
Concord, N. H.	14.9	14.0	14.3	13.0	13.0	11.7	12.6	14.1	14.2	14.2	15.4	14.6
Boston, Mass.	13.0	12.3	12.3	12.0	12.3	10.9	11.7	12.6	12.9	12.7	13.0	11.9
Providence, R. I.	13.7	12.4	13.1	12.4	12.9	12.1	12.6	14.5	14.6	14.2	13.6	11.8
Bridgeport, Conn.	14.8	12.3	13.4	12.9	13.0	12.6	13.2	14.1	14.3	13.6	14.5	13.2
New York, N. Y.	13.7	11.7	12.7	11.7	12.6	11.2	11.3	12.2	12.0	11.9	12.6	12.5
Newark, N. J.	14.0	11.9	13.2	12.0	12.4	11.4	11.5	12.9	13.0	12.3	13.3	13.4
Wilmington, Del.	15.1	12.1	13.4	12.3	13.4	12.7	12.6	12.9	14.5	13.9	14.6	13.7
Philadelphia, Pa.	14.3	11.3	12.4	11.9	12.7	12.0	11.7	13.5	13.3	12.3	13.0	12.9
Baltimore, Md.	13.7	10.8	12.5	11.7	12.9	12.2	11.8	13.3	13.3	12.3	13.6	13.0
Norfolk, Va.	13.9	12.7	13.0	12.4	13.0	13.2	13.4	14.9	14.5	14.7	14.5	14.0
Wilmington, N. C.	15.7	15.4	15.0	13.7	13.5	13.5	15.4	16.7	16.8	15.8	15.9	16.3
Charleston, S. C.	14.8	15.1	13.2	13.4	14.1	15.5	16.2	16.8	17.3	16.1	15.6	16.0
Savannah, Ga.	14.3	14.7	12.5	12.9	12.9	13.9	14.5	15.4	15.6	14.3	14.6	15.4
Key West, Fla.	14.7	14.7	14.3	12.9	13.7	14.0	14.0	13.0	14.5	16.3	15.9	14.8
Burlington, Vt.	14.9	14.3	14.9	13.1	13.0	11.7	11.8	13.1	14.7	14.5	14.6	14.9
Cleveland, Ohio	16.9	14.9	15.0	13.6	13.0	11.8	11.6	12.6	12.2	10.0	13.3	15.2
South Bend, Ind.	18.9	15.4	15.2	13.3	14.1	13.0	12.9	14.5	13.7	13.3	14.3	17.4
Charleston, W. Va.	14.3	12.1	12.0	11.9	12.7	13.8	14.1	13.8	12.6	11.7	12.2	13.4
Louiseville, Ky.	15.4	12.8	12.9	12.3	12.8	12.2	12.0	11.8	11.3	11.5	11.9	14.3
Nashville, Tenn.	15.4	14.0	12.9	12.1	12.3	11.4	11.8	11.9	11.8	11.7	12.0	14.8
Mobile, Ala.	15.8	16.2	14.6	13.3	15.0	14.2	15.4	16.7	14.3	12.0	13.0	14.9
Jackson, Miss.	14.7	14.5	12.6	12.7	13.5	11.9	12.7	12.5	11.4	10.3	11.5	13.9
Detroit, Mich.	17.5	14.3	15.2	12.2	12.2	11.4	11.5	12.4	12.5	11.9	14.0	15.8
Milwaukee, Wis.	15.8	14.6	14.9	12.4	13.0	13.7	13.2	14.2	13.0	11.8	13.2	15.8
Chicago, Ill.	16.1	13.7	14.2	11.8	12.4	11.9	11.9	12.5	11.6	10.9	10.3	15.2
Des Moines, Iowa	16.9	16.0	14.9	12.4	12.8	13.6	13.5	13.3	11.6	10.1	12.4	16.4
Kansas City, Mo.	14.3	13.1	13.4	12.0	12.5	10.3	10.9	11.1	9.5	9.3	11.2	13.7
Little Rock, Ark.	15.7	13.6	12.7	12.5	13.6	11.7	12.0	12.5	11.2	10.6	11.8	13.7
New Orleans, La.	16.2	15.6	14.0	13.4	14.6	14.5	15.7	17.1	16.8	13.1	14.5	15.3
Duluth, Minn.	15.5	15.2	16.0	12.8	12.7	14.9	14.8	16.1	16.5	13.9	15.9	16.9
Bismark, N. Dak.	17.2	17.6	17.0	12.4	11.9	12.9	11.6	11.6	11.2	11.0	14.3	16.1
Huron, S. Dak.	17.0	18.0	16.0	12.7	12.1	13.0	11.8	12.2	10.1	10.2	13.4	17.6
Omaha. Nebr.	18.0	15.5	15.2	12.2	12.6	11.3	12.1	12.9	11.3	10.4	12.4	15.7
Wichita, Kans.	13.7	12.4	13.0	12.0	11.9	9.9	11.0	10.5	8.3	8.5	11.9	15.5
Tulsa, Okla.	14.0	12.2	12.2	12.6	12.6	11.0	12.4	11.2	9.7	9.7	12.0	12.7
Galveston, Tex.	18.2	18.2	18.1	15.8	16.9	15.7	15.4	15.7	15.5	14.2	16.6	15.9
Missoula, Mont.	16.1	15.1	12.5	10.2	11.6	11.5	8.2	8.7	9.3	10.5	14.6	16.4
Casper, Wyo.	11.0	12.3	11.5	10.3	11.2	8.4	8.6	8.1	7.0	8.2	11.0	12.8
Denver, Colo.	8.4	8.3	9.3	10.3	9.8	7.6	8.2	8.9	6.9	7.2	9.9	10.4
Salt Lake City, Utah	14.3	12.5	12.4	10.8	9.3	7.8	7.8	7.4	7.5	9.1	12.1	15.8
Albuquerque, N. Mex.	9.2	8.1	8.0	6.9	6.3	5.7	7.9	7.7	7.1	6.9	10.5	11.1
Tucson, Ariz.	8.8	7.0	7.9	6.8	5.3	4.6	8.1	8.0	5.2	5.2	7.7	8.0
Boise, Idaho	15.8	14.3	12.1	10.3	10.9	10.5	7.3	7.3	7.6	8.6	10.3	18.0
Reno, Nev.	13.2	11.3	11.0	9.4	9.0	8.6	8.0	7.8	8.9	9.6	11.3	13.4
Seattle-Tacoma, Wash.	21.0	18.9	16.8	14.8	14.2	15.3	13.7	14.6	14.7	17.2	18.9	18.9
Portland, Oreg.	19.6	16.8	14.7	13.0	14.1	14.5	12.1	13.4	13.1	15.9	18.5	20.0
San Francisco, Calif.	18.5	14.8	14.7	16.0	14.7	15.6	15.8	16.6	15.5	15.9	16.0	16.3
Juneau, Alaska	19.8	20.2	17.9	15.8	16.3	14.8	16.2	18.2	21.4	....	22.0	18.6
San Juan, P. R.	14.7	15.3	14.4	15.2	14.6	15.7	16.2	15.7	15.7	15.7	15.5	14.7
Honolulu, T. H.	13.8	13.5	13.2	12.6	12.0	12.1	12.3	12.6	11.9	12.8	12.9	13.5

[1] The values were calculated by means of the average monthly temperatures and relative humidities given in Climatological Data monthly reports for 1952 and 1953 of the Weather Bureau, and wood equilibrium moisture content diagrams.

Z M 97949 F

Table 2.--Effect of 90 days storage on the average and on the moisture content of the wettest board in lots of rough and dressed longleaf and shortleaf pine

Grade and species	Average moisture content		Wettest board	
	Fresh from kiln	After storage	Fresh from kiln	After storage
	Percent	Percent	Percent	Percent
C and Better				
Longleaf				
Rough	5.9	8.1	15.5	12.8
Dressed	7.4	9.1	14.7	15.9
Shortleaf				
Rough	6.6	9.8	22.2	14.9
Dressed	5.9	9.5	15.2	15.4
Flooring				
Longleaf				
Rough	6.1	7.9	14.2	12.9
Dressed	8.1	9.5	18.2	16.0
Shortleaf				
Rough	6.9	10.9	21.0	18.1
Dressed	6.6	11.6	17.1	17.6
No. 1 Common				
Longleaf				
Rough	7.2	8.6	15.9	14.7
Dressed	7.2	8.6	17.4	12.7
Shortleaf				
Rough	7.2	10.1	24.9	16.4
Dressed	8.0	11.4	21.5	17.4
No. 2 Common				
Longleaf				
Rough	8.0	9.1	19.1	13.3
Dressed	7.6	9.1	18.7	13.3
Shortleaf				
Rough	7.6	10.7	19.3	16.4
Dressed	8.4	12.3	24.9	20.4

Figure 1.--Concrete runways beneath a pile for the wheels of a fork-lift truck. Note that the pile is sloped.

Z M 98296 F

Figure 2.--Storage-yard piles of strapped solid packages, separated by bolsters, with foundations of solid blocked-up beams.

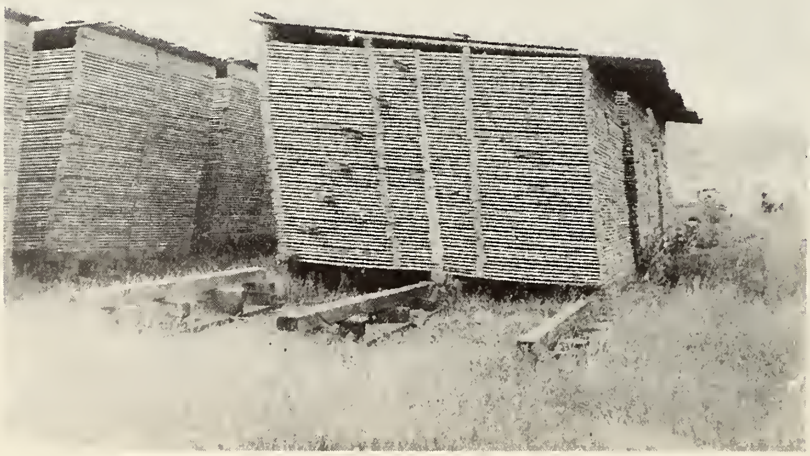

Figure 3.--Hand-stacked, stickered storage-yard piles. The piles are sloped and pitched. The roof, made from two lengths of boards placed in two layers, projects about 1 foot at the front and about 3 feet at the rear.

Z M 90525 F

Figure 4.--A post-timber type of pile foundation with the posts braced against lateral tipping. The foundation provides ample ground clearance. (These are experimental piles.)

Z M 98089 F

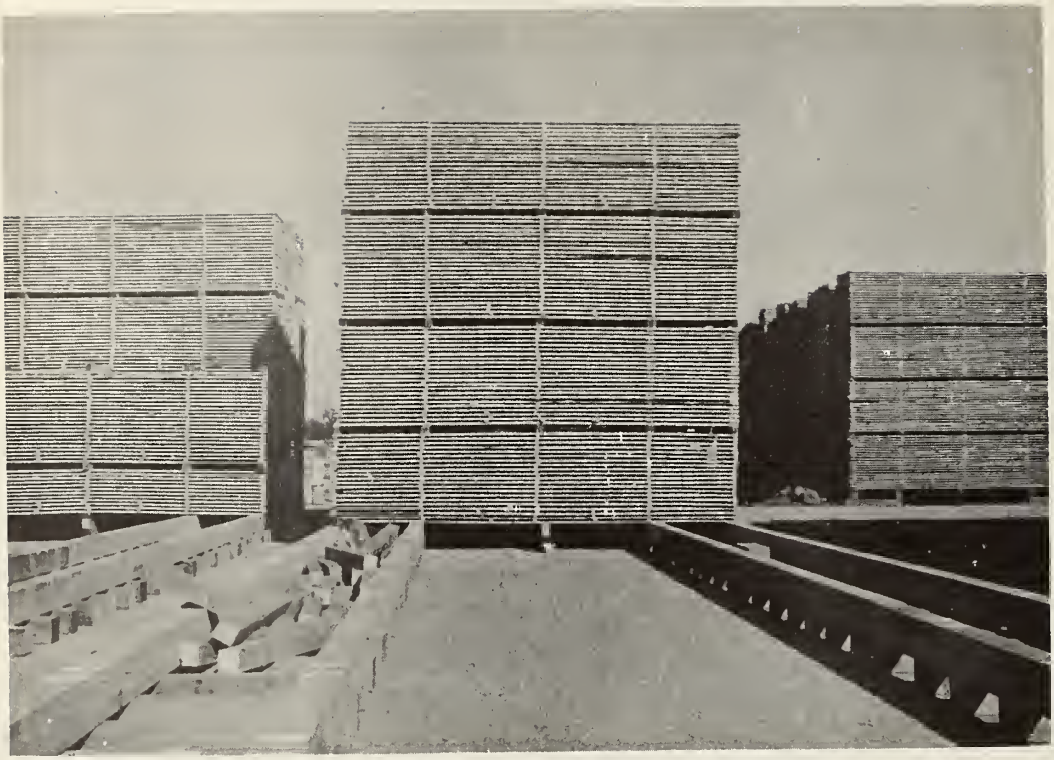

Figure 5.--Fixed-timber type of foundation for piles of stickered unit packages built by fork-lift truck. Special stickers are used. The foundation timbers, bolsters, and tiers of stickers are in good alinement.

Z M 98792 F

Figure 6.--Corner of a hand-stacked storage-yard pile with stock stickers. Vertical flues were built into the pile by edge spacing.

Z M 98396 F

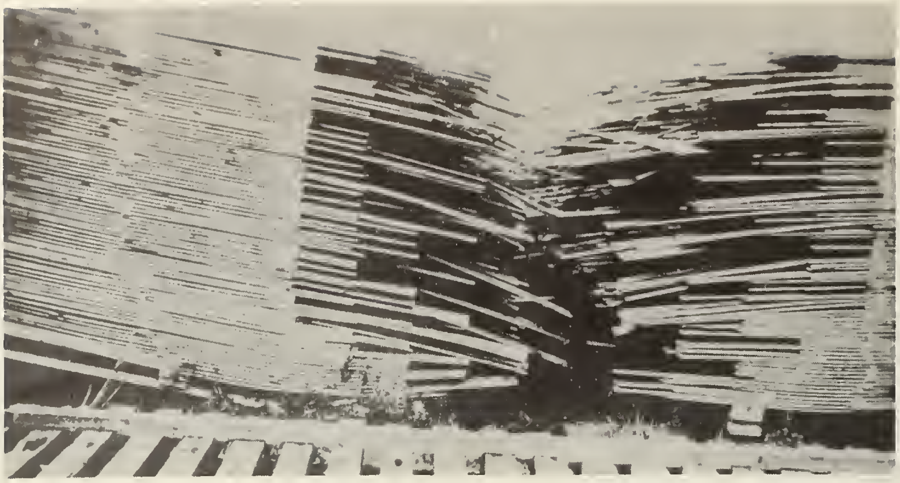

Figure 7.--Sagging of boards in a hand-stacked pile caused by poorly alined stickers and foundation timbers.

Figure 8.--Sagging of boards in stickered unit packages caused by poorly alined stickers and bolsters.

Z M 90524 F

Figure 9.--Building a stickered unit package at the door of a railroad car. The framework carrying the sticker guides is mounted on casters.

Z M 98281 F

Figure 10.--Box piling a stickered unit package. The outer tiers are composed of long boards.

Z M 98512 F

Figure 11.--Fork-lift trucks piling solid packages in an open storage shed. One side of the shed is open.

Z M 90527 F

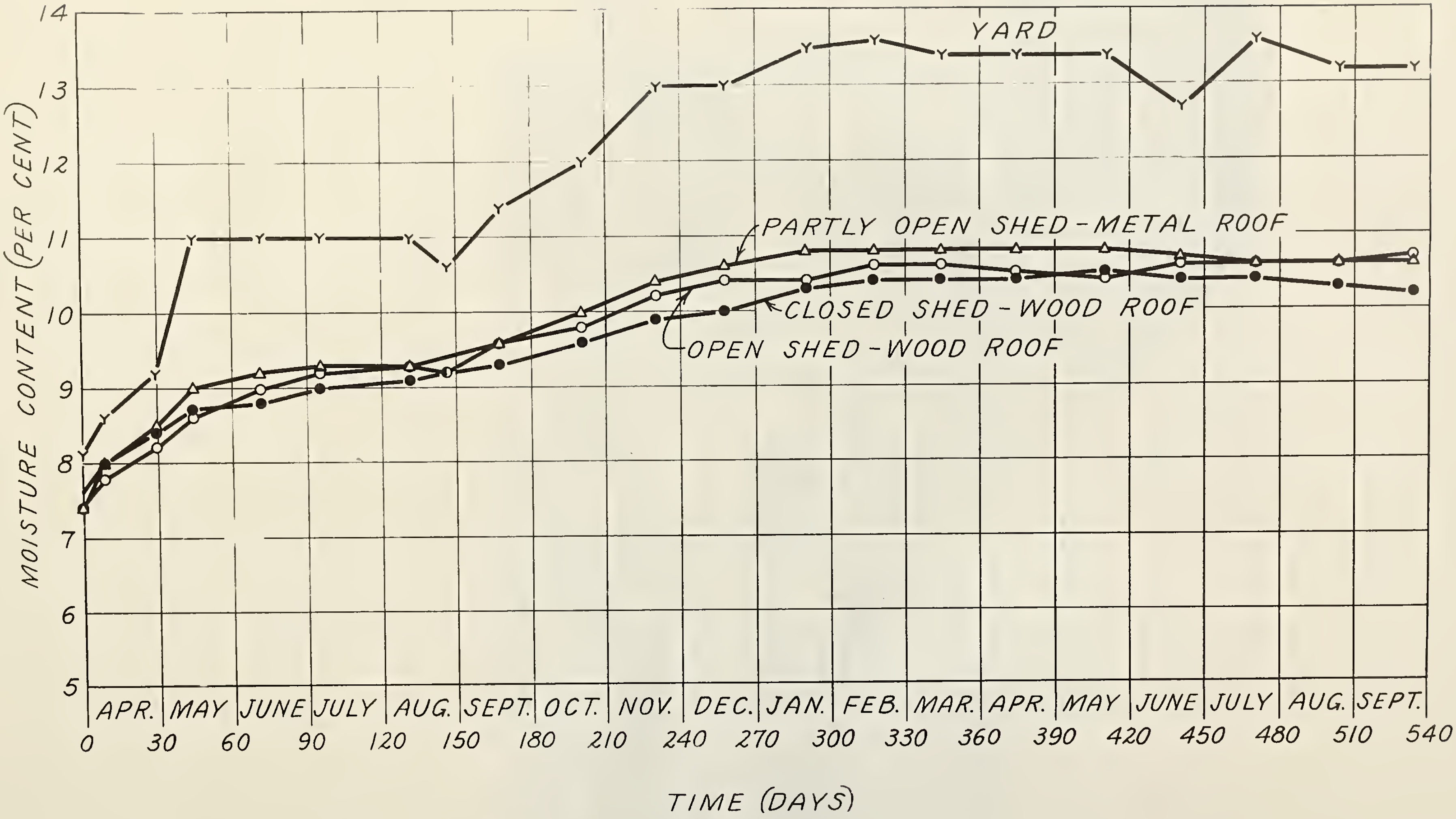

Figure 12.--Changes in average moisture content of kiln-dried southern yellow pine 1- by 4-inch flooring and 1- by 8-inch dressed boards during storage in solid piles.

Z M 20453 F

Figure 13.--Unit packages of lumber waiting to be kiln dried, stored in a closed shed. The fork-lift truck, in the center aisle, is placing a unit package on a pile in one of the bays.

Z M 105 855

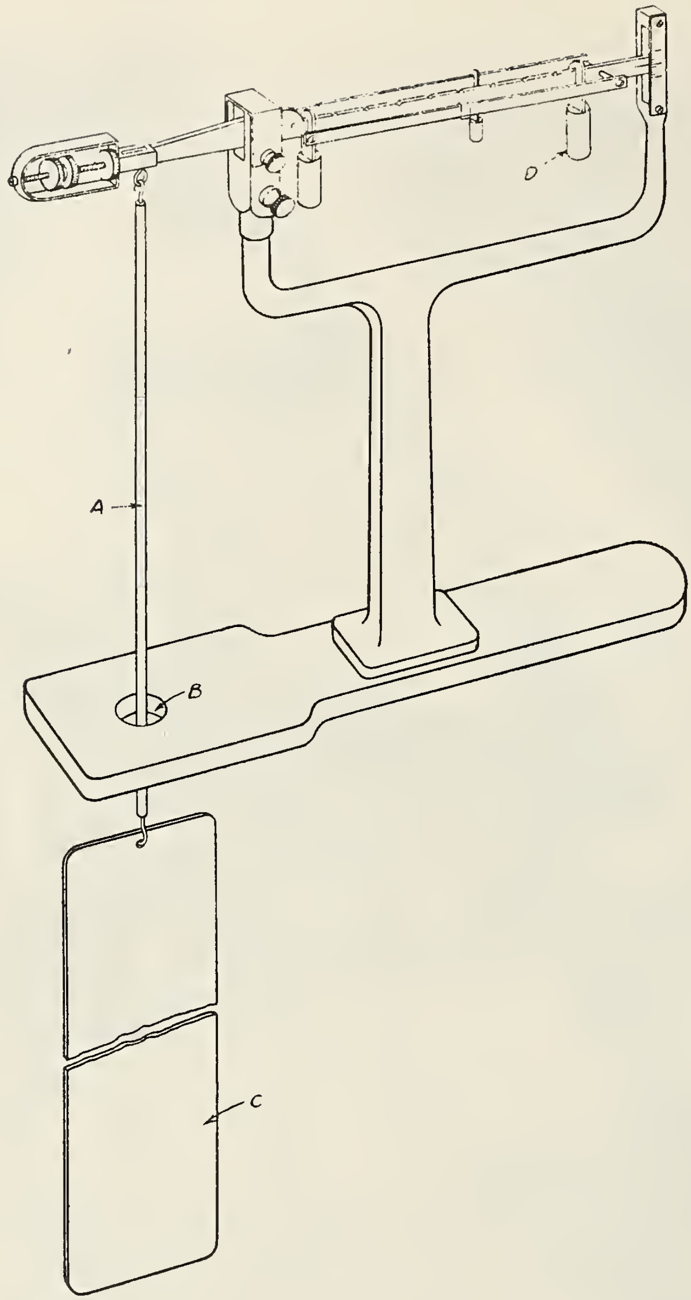

Figure 14.--Method of using calibrated wood strip for determining equilibrium moisture content of a heated storage shed. Brass tube A extends through hole B to wood strip C, which weighs 100 grams when ovendry.

Z M 105 737

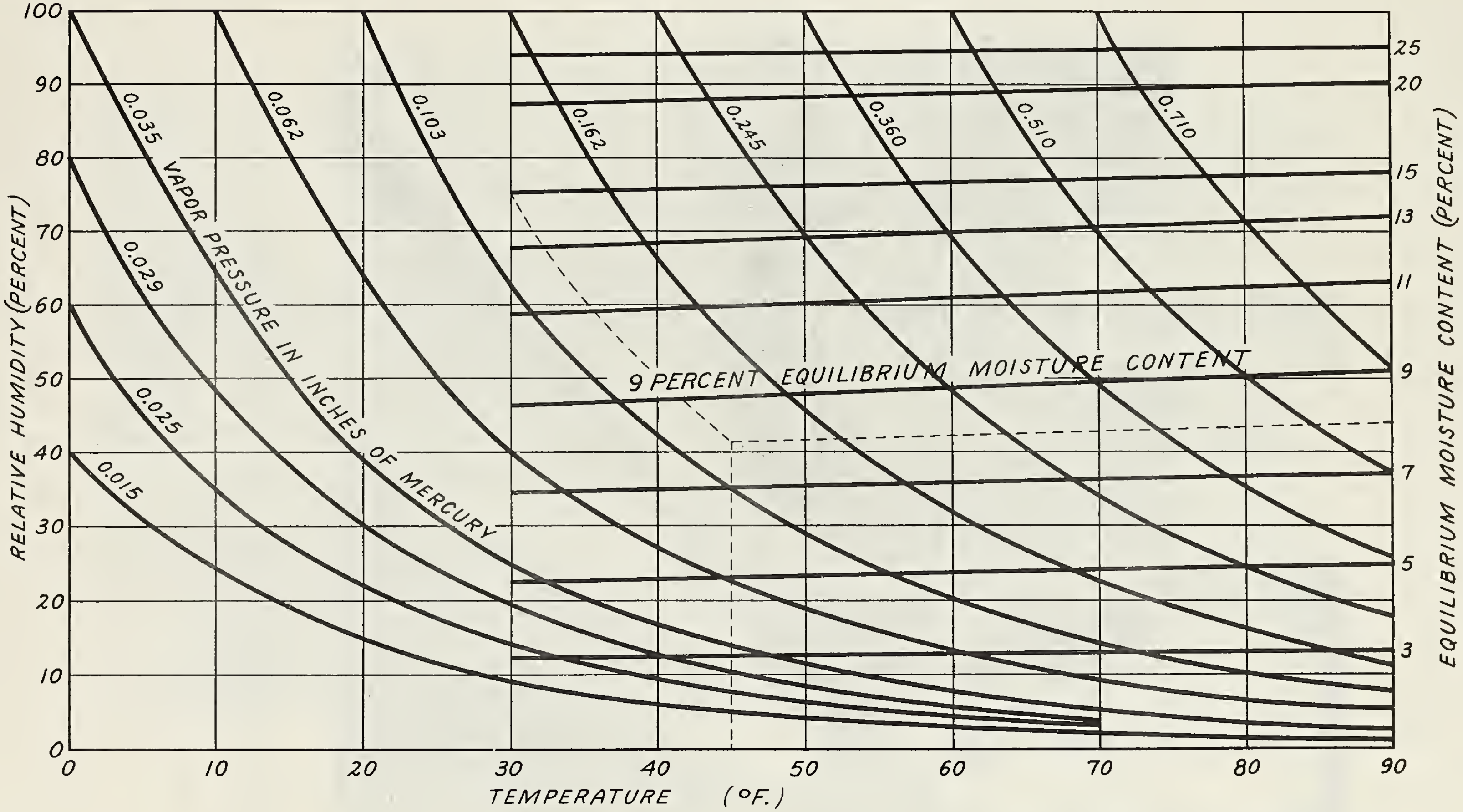

Figure 15.--Chart showing the effect of heating or cooling of air on the relative humidity of the air and on the equilibrium moisture content of wood.

Z M 44797 F

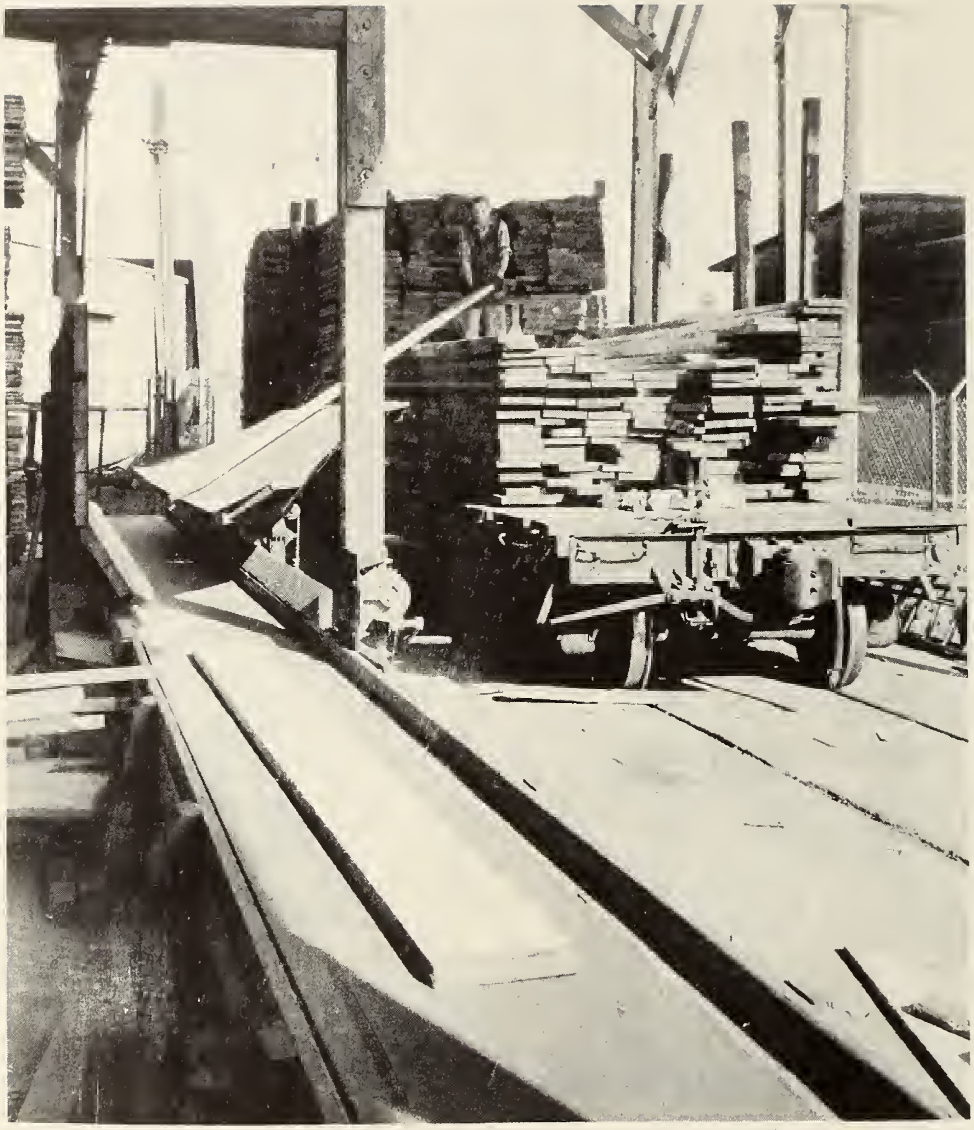

Figure 16.--Conveyor belt for carrying boards away from railroad car.

Z M 90526 F

Figure 17.--Lack of strapping caused this package of lumber to spill. Strapped packages are preferred for machine handling and for shipment.

Z M 83675 F

Figure 18.--Unloading strapped solid packages from a flat car by tractor crane. Fork-lift trucks are also used in unloading railroad cars.

Z M 86520 F

Figure 19.--Straddle truck carrying a solid package of lumber. When large volumes of lumber are handled, the use of straddle trucks for transporting and fork-lift trucks for piling and unpiling is efficient.

Z M 90383 F

SUBJECT LISTS OF PUBLICATIONS ISSUED BY THE

FOREST PRODUCTS LABORATORY

The following are obtainable free on request from the Director, Forest Products Laboratory, Madison 5, Wisconsin:

List of publications on Box and Crate Construction and Packaging Data

List of publications on Chemistry of Wood and Derived Products

List of publications on Fungus Defects in Forest Products and Decay in Trees

List of publications on Glue, Glued Products and Veneer

List of publications on Growth, Structure, and Identification of Wood

List of publications on Mechanical Properties and Structural Uses of Wood and Wood Products

Partial list of publications for Architects, Builders, Engineers, and Retail Lumbermen

List of publications on Fire Protection

List of publications on Logging, Milling, and Utilization of Timber Products

List of publications on Pulp and Paper

List of publications on Seasoning of Wood

List of publications on Structural Sandwich, Plastic Laminates, and Wood-Base Aircraft Components

List of publications on Wood Finishing

List of publications on Wood Preservation

Partial list of publications for Furniture Manufacturers, Woodworkers and Teachers of Woodshop Practice

Note: Since Forest Products Laboratory publications are so varied in subject no single list is issued. Instead a list is made up for each Laboratory division. Twice a year, December 31 and June 30, a list is made up showing new reports for the previous six months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. Each subject list carries descriptions of all other subject lists.

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